



EDUCATION

What Can TIMSS Surveys Tell Us About 1990s Mathematics Reform in the U.S.?

Laura Hamilton

RAND Corporation

José Felipe Martinez

RAND Corporation and UCLA

DRAFT: Not for citation or attribution. The opinions expressed in this presentation do not reflect the views of RAND or its sponsors.

Many Schools in U.S. Adopted New Math Curricula During the 1990s

- ▣ National Council of Teachers of Mathematics (NCTM) influenced some curriculum decisions
- ▣ New curricula were intended to promote problem solving, inquiry, communication
- ▣ So-called “reform-oriented instruction” is associated with specific activities
 - Cooperative groups
 - Open-ended problem solving
 - Writing about mathematics
 - Use of calculators (under certain circumstances)
- ▣ Reform approach also often includes greater depth, less breadth of topic coverage
- ▣ Approach does *not* require de-emphasizing computational skills

NCTM-Aligned Curricula Provided Fodder for the “Math Wars”

- ▣ Competing “reform” and “traditional” camps have criticized each other’s philosophy and approach
- ▣ TIMSS, NAEP, and other large-scale assessments have fueled concerns about de-emphasis of basic skills, including computation
- ▣ Are there signs of a cease-fire in the math wars?
 - NCTM’s 2006 *Curriculum Focal Points* has been described as a return to basics
 - But NCTM leaders dispute the notion that the *Focal Points* represents a change in their views

Reform and Traditional Approaches are Not Necessarily in Opposition

- ▣ Much of the math wars debate oversimplifies the distinction
- ▣ Some studies suggest use of reform practices is uncorrelated with use of traditional practices
- ▣ Studies of instructional effects must recognize that reform doesn't necessarily mean an absence of basic skills

Several Studies have Examined Reform-Oriented Mathematics Instruction

- ▣ Survey, interview, and observational data suggest use of practices consistent with reform is relatively rare
- ▣ Small-scale studies point to positive relationships between reform practices and achievement
- ▣ Results of large-scale studies are mixed
 - Mostly null or small positive relationships
 - Some achievement measures appear more sensitive to reform effects than others
 - Conclusions are limited by weak measures and study designs

Can TIMSS Survey Analysis Contribute to the Debate?

- ▣ TIMSS teacher surveys have been used in the past to investigate reform-oriented instruction
- ▣ TIMSS includes several relevant data sources
 - Teacher surveys of practices and topic coverage
 - Student surveys of teachers' practices
 - Student achievement data
- ▣ TIMSS provides opportunity for international comparisons of practices
- ▣ TIMSS video studies have been used to investigate practices but this study focuses on surveys

This Study Addresses Four Questions

- ▣ How has teachers' reported use of reform-oriented instruction changed over time?
- ▣ How are teachers' opinions about mathematics teaching related to their practices?
- ▣ How well do student and teacher reports of practices match?
- ▣ What is the relationship between reform-oriented practices and student achievement?

Today's presentation focuses on the first and fourth questions.

Study Used TIMSS Data from Teachers and Students

- ▣ Focus on 8th grade
- ▣ Select three countries for comparison: Japan, the Netherlands, Singapore
- ▣ Identify survey items that measure practices
 - Teacher survey
 - Student survey
- ▣ All analyses are weighted; estimates are for nationally representative samples of students (not teachers)

Four Scales Created from Teacher Survey

- ▣ **Reform practices (focus of our analysis): How often teacher asks students to**
 - **Work on problems with no immediately obvious method of solution**
 - **Work together in small groups**
 - **Relate what they are learning in mathematics to their daily lives**
 - **Explain their answers**
 - **Decide on their own procedures for solving complex problems**
- ▣ **Content coverage**
- ▣ **Reform perceptions**
- ▣ **Traditional perceptions**

Student Survey Scales Were Not Created

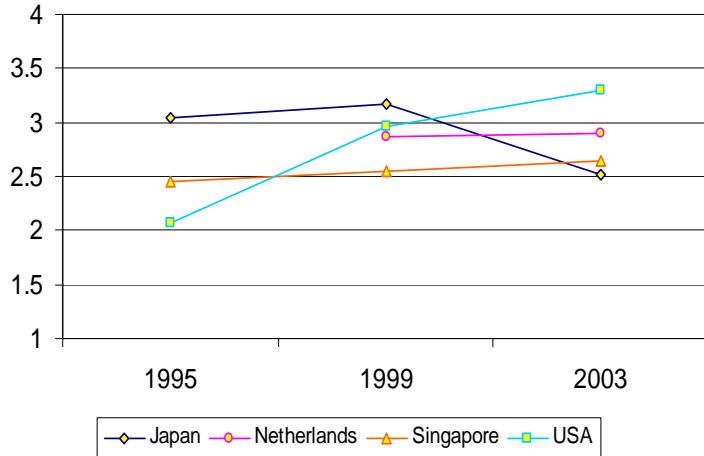
- ▣ Student survey items on instructional practices did not lend themselves to composites
- ▣ Teacher and student items had some overlap in content, but not complete
- ▣ Correlations between teacher and student responses were low
- ▣ Within-class variability in student responses was high
- ▣ We include three items in our multilevel models
 - Work problems on our own
 - Listen to the teacher give a lecture-style presentation
 - Use calculators

How Has Use of Reform Practices Changed Over Time?

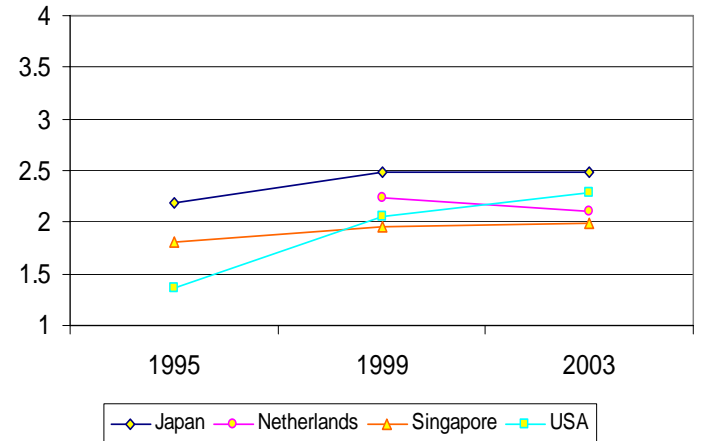
- ▣ Changes in survey items hinder comparisons of practices across TIMSS waves
- ▣ Four items were identical or nearly identical in all three waves
 - Three are consistent with reform approach
 - A fourth addresses computational skills
- ▣ Examination of changes reported by teachers in the U.S. and elsewhere provides suggestive evidence about the effects of 1990s reforms

U.S. Teachers Reported Changes in Practices, Especially from 1995 to 1999

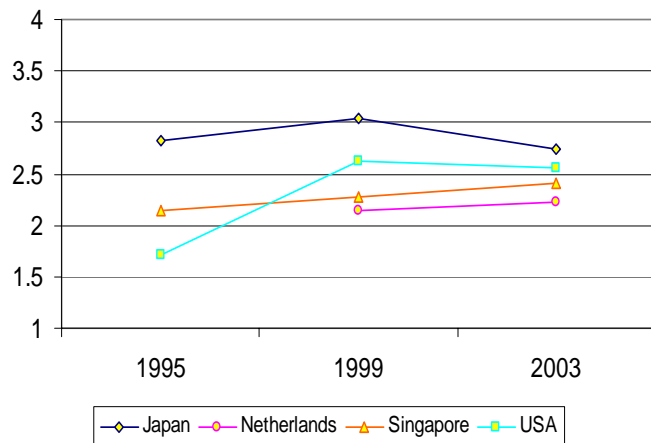
Explain Reasoning/Answers



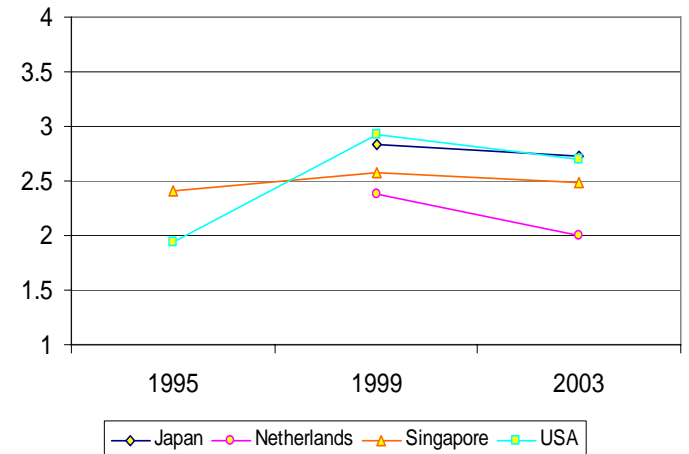
Problem Solving



Writing Equations to Represent Relationships



Computational Skills



How Has Topic Coverage Changed?

- ▣ **Changes in survey items hinder comparisons of topic coverage**
 - **Number of topics about which teachers were asked varied (37 in 1995, 34 in 1999, and 45 in 2003)**
 - **Wording of question and response scale also varied**
- ▣ **Analysis focuses on percentage of topics taught from the entire set included in the survey**
- ▣ **Analysis was conducted separately for algebra and non-algebra classes (possible only in 2003, and relevant only in U.S.)**

Proportion of Topics Taught Changed in U.S. and Elsewhere

| | Proportion of topics taught | | |
|-------------|-----------------------------|------|----------------------------------|
| | 1995 | 1999 | 2003 |
| Japan | 28.8 | 29.1 | 24.5 |
| Netherlands | 42.7 | 36.2 | 41.5 |
| Singapore | 38.9 | 24.4 | 39.2 |
| USA | 49.1 | 42.6 | 46.1 (Overall) 24.0 (Algebra) |

Results are Consistent with Other Work on Curriculum in U.S. and Elsewhere

- ▣ U.S. teachers consistently report greater topic coverage than teachers in other nations
 - Exception is for algebra classes

- ▣ Dip in 1999 for 3 countries might reflect the effects of survey wording rather than a real change

- ▣ At best, analysis provides suggestive evidence that 1990s mathematics reforms might have influenced instruction (or at least how teachers talk about instruction)

Are Reform-Oriented Practices Related to Student Achievement?

- ▣ Summarized average achievement in each country
- ▣ Estimated a series of two-level hierarchical linear models (students nested within teachers)
- ▣ Estimated unconditional models to examine variation in achievement within and across classrooms in:
 - Student-reported instructional practice
 - Student achievement (between-classroom variance creates a ceiling for the effects of teacher-level variables)

Multilevel Modeling Was Used to Explore Practice/Achievement Relationships

- ▣ Explored within-country relationships between achievement and several predictors, including reform-oriented practices
 - Student weights are used
 - Each model is estimated 5 times, once for each plausible value, and the results are combined into final parameter and standard error estimates
- ▣ Controlled for available student and teacher background characteristics

Lack of experimental design and lack of prior test scores for students hinders ability to make strong conclusions

U.S. Scores Were Lowest in Almost all Cases

| | Japan | Netherlands | Singapore | U.S. |
|------------------------------------|--------------|--------------|--------------|--------------|
| Total Mathematics Score | 568.0 | 530.5 | 602.9 | 505.1 |
| Data, Analysis, Probability | 571.2 | 555.1 | 577.2 | 527.8 |
| Fractions, Number Sense | 554.5 | 533.1 | 615.1 | 508.4 |
| Geometry | 585.3 | 507.7 | 577.3 | 472.9 |
| Algebra | 566.1 | 508.5 | 587.2 | 510.6 |
| Measurement | 557.3 | 543.3 | 608.1 | 496.2 |

Between-Class Variability was Greater in Singapore and U.S. than in Japan and the Netherlands

| Proportion of Variance between classrooms | Japan | Netherlands | Singapore | U.S. |
|--------------------------------------------------|--------------|--------------------|------------------|-------------|
| Total Mathematics Score | 12.0 | 42.5 | 76.8 | 63.4 |
| Data, Analysis, Probability | 8.1 | 35.0 | 59.9 | 51.4 |
| Fractions, Number Sense | 11.7 | 41.1 | 73.6 | 62.1 |
| Geometry | 8.8 | 34.9 | 70.4 | 53.4 |
| Algebra | 10.1 | 39.5 | 65.9 | 59.3 |
| Measurement | 11.4 | 39.1 | 70.8 | 57.7 |
| Number of Students | 4147 | 2397 | 5214 | 6841 |
| Number of Classrooms | 125 | 103 | 283 | 346 |

Reform-Achievement Relationships Were Small When Examining Total Math Score and Subscores Other Than Algebra

- ▣ **Students' reports of working problems on their own were positively related to achievement in all countries**
- ▣ **Student reports of lectures were negatively related to achievement but only in the U.S.**
- ▣ **Effect sizes for student-reported practices were small**
- ▣ **Relationship between teacher-reported reform practices and achievement was positive and significant in Singapore only**

Models Using Algebra Showed Somewhat Different Patterns

- ▣ Relationships with student survey items were similar to models using total scores
- ▣ But coefficients for teacher reform practices were positive and significant for algebra in U.S., Japan, and Singapore
- ▣ Effect sizes were moderate
- ▣ No relationships between achievement and time spent on algebra or interaction between time and reform practices

Findings Provide Some Evidence that NCTM-Aligned Reforms Took Hold

- ▣ Teachers in the U.S. reported increases in reform-oriented practices and decreases in number of topics taught
- ▣ But these survey data provide only a limited view into the classroom
- ▣ Validity problems aside, there is little evidence that reform-oriented teaching is associated with improved student achievement

This Study Has Several Limitations

- ▣ **Survey validity concerns**
- ▣ **Incomplete nature of information about practices**
- ▣ **Other challenges associated with large-scale survey studies**

Many of the limitations apply to other studies of reform-oriented instruction

Validity of Survey Responses is Questionable

- ▣ Focus more on activities than on attention to students' thinking
- ▣ Responses might be affected by social desirability
- ▣ Responses are also influenced by teachers' prior experiences and understanding of terms
 - Especially problematic for cross-cultural comparisons
- ▣ Teacher-level items ignore differences in the experiences of students within the same classroom
- ▣ No information on quality of instruction

Reform Implementation Involves More than Just Pedagogy

- ▣ Curriculum and content of instruction are critical
- ▣ Studies show interactions between pedagogy and curriculum
- ▣ Integration of topics (e.g., algebra) is central to reform principles
- ▣ Some promising approaches gather information on both content and cognitive demand

Large-Scale Surveys Often Have Additional Limitations

- ▣ Study designs typically cannot support strong causal inferences
- ▣ Measurement of achievement are often insufficient for detecting specific instructional effects

Where to Go from Here?

- ▣ **Consider other cost-effective strategies for gathering data on curriculum and instruction**
- ▣ **Gather information on opportunity to learn at the *student* level**
- ▣ **Address external, contextual factors that influence instruction and achievement**
 - **District support for reform**
 - **Competing initiatives**
 - **Test-based accountability policies**